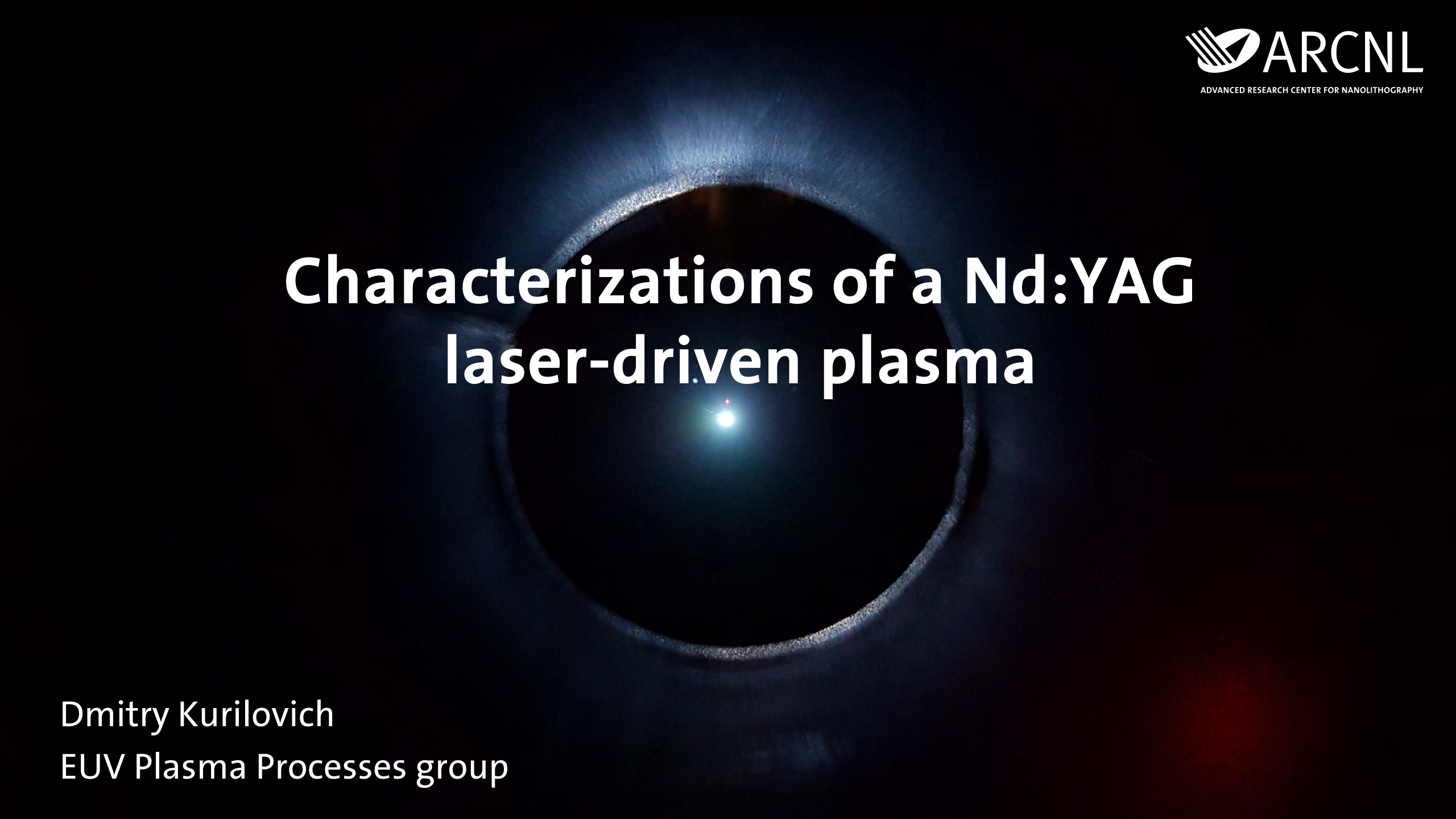


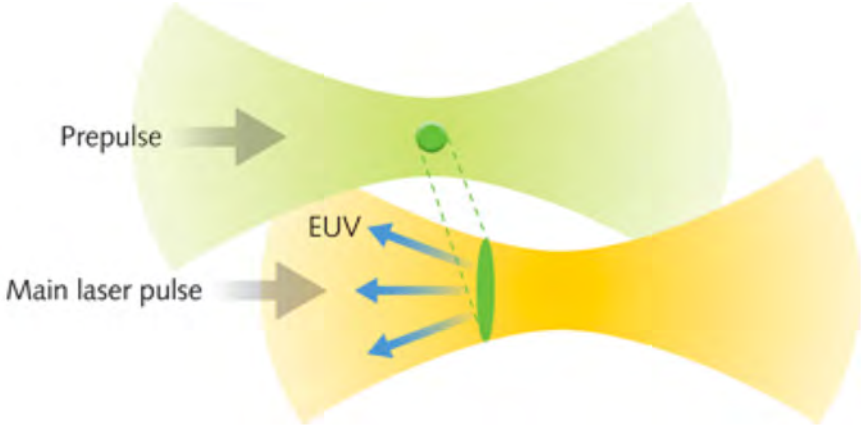
ARCNL
ADVANCED RESEARCH CENTER FOR NANOLITHOGRAPHY

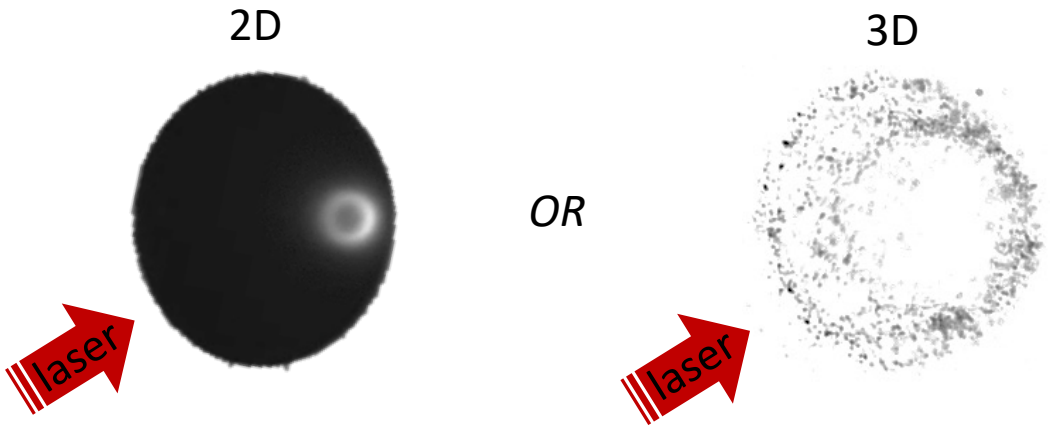
Characterizations of a Nd:YAG laser-driven plasma

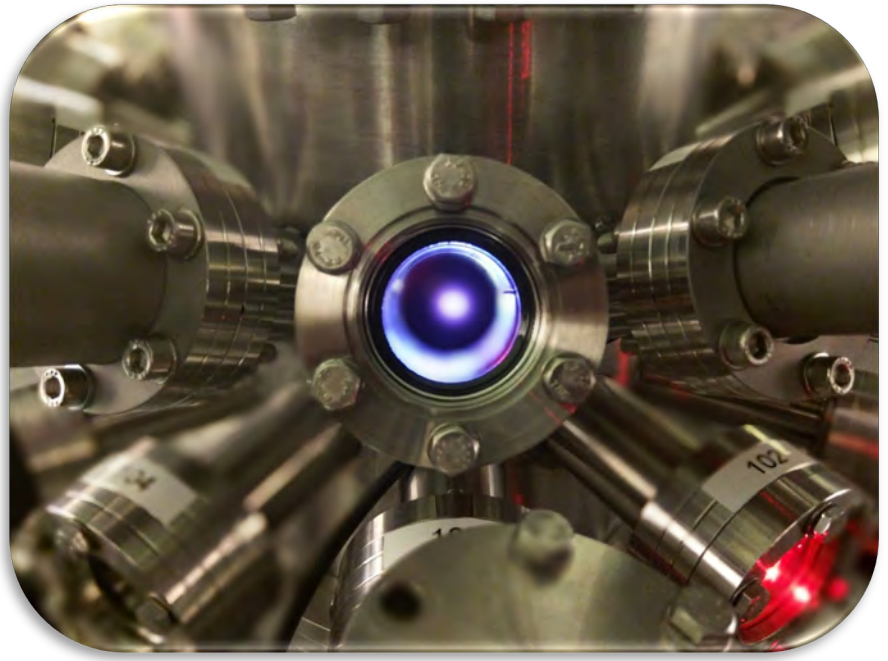
Dmitry Kurilovich
EUV Plasma Processes group

Droplet-based EUV light source

Pre-pulse technique for target preparation

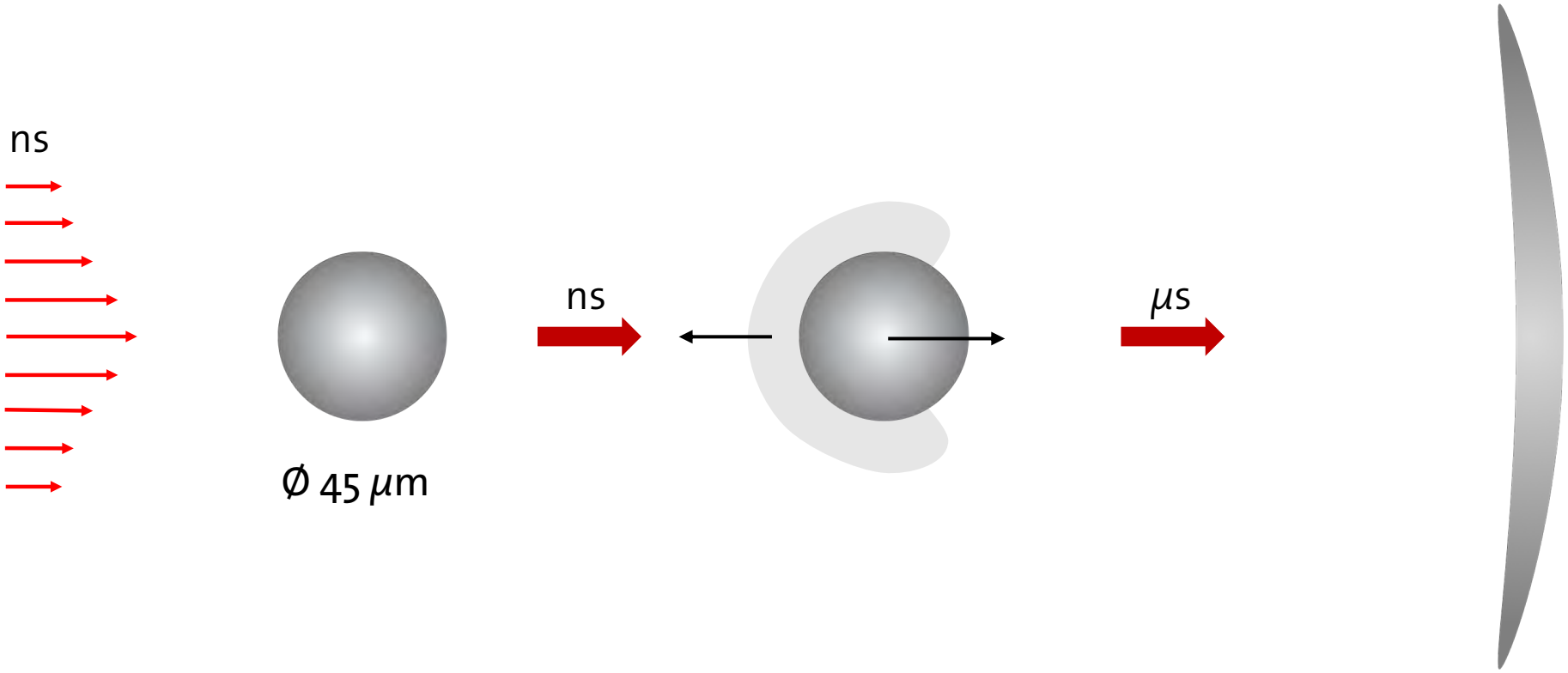






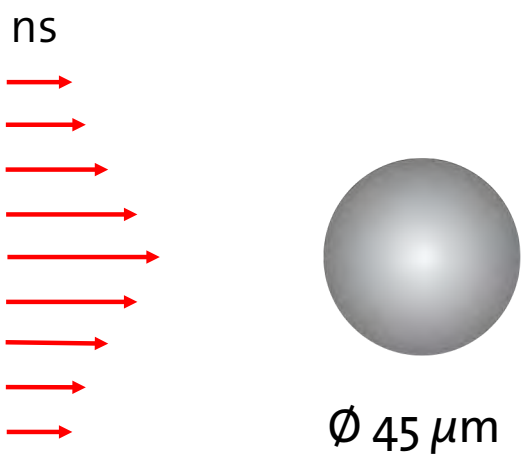
ns-laser-driven droplet expansion

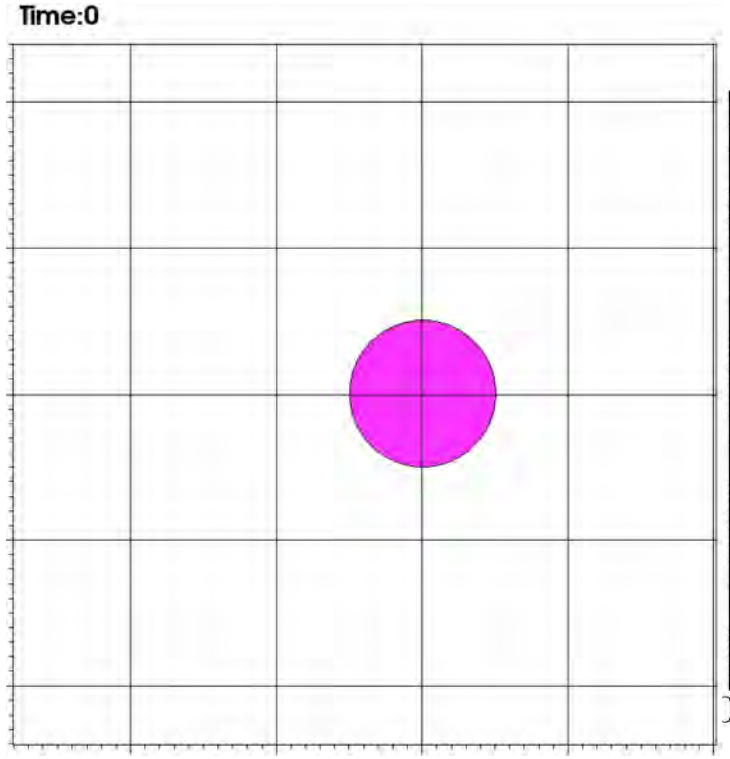
Propulsion and deformation of tin droplet

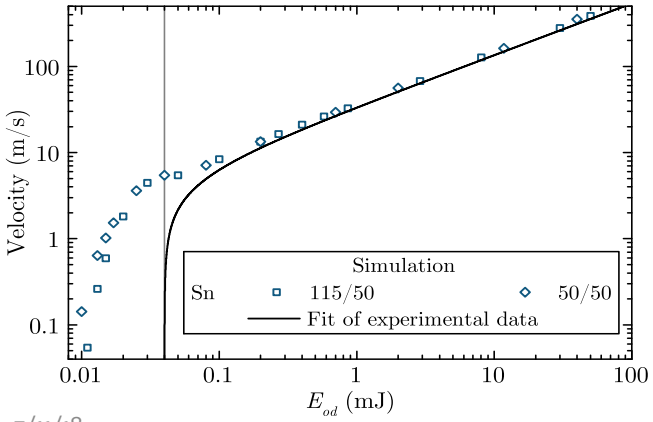


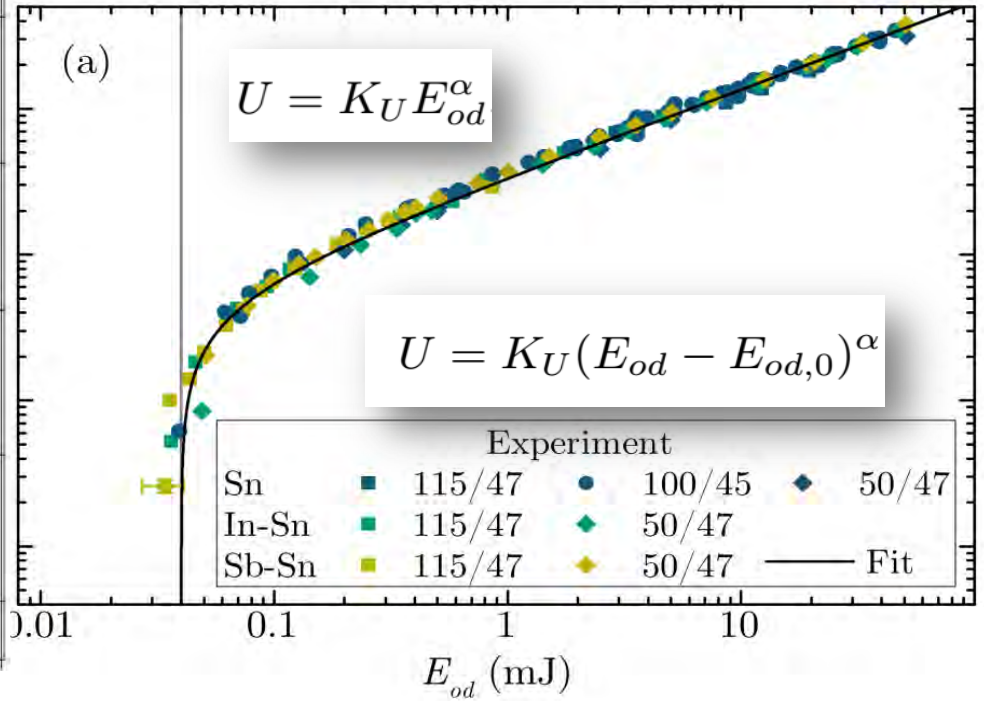
ns-laser-driven droplet expansion

Propulsion and deformation of tin droplet





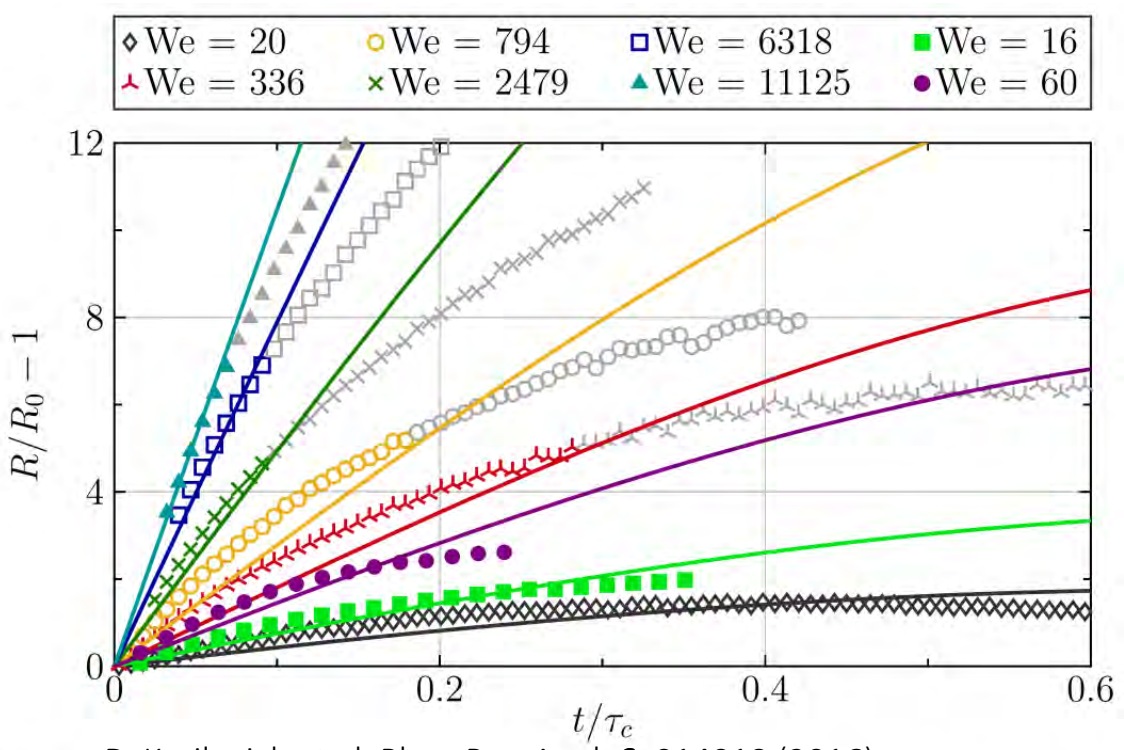




D. Kurilovich et al, Phys. Plasmas **25**, 012709 (2018)

ns-laser-driven droplet expansion

Propulsion and deformation of tin droplet



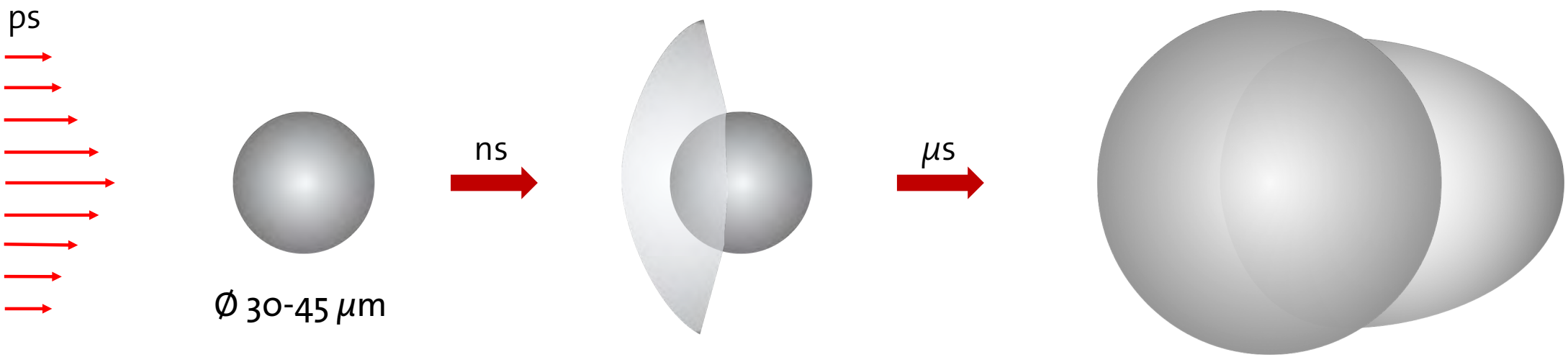
D. Kurilovich et al, Phys. Rev. Appl. **6**, 014018 (2016);
H. Gelderblom, JFM **794**, 676 (2016);

$$We \propto E_{kin}/E_{surf}$$

μs

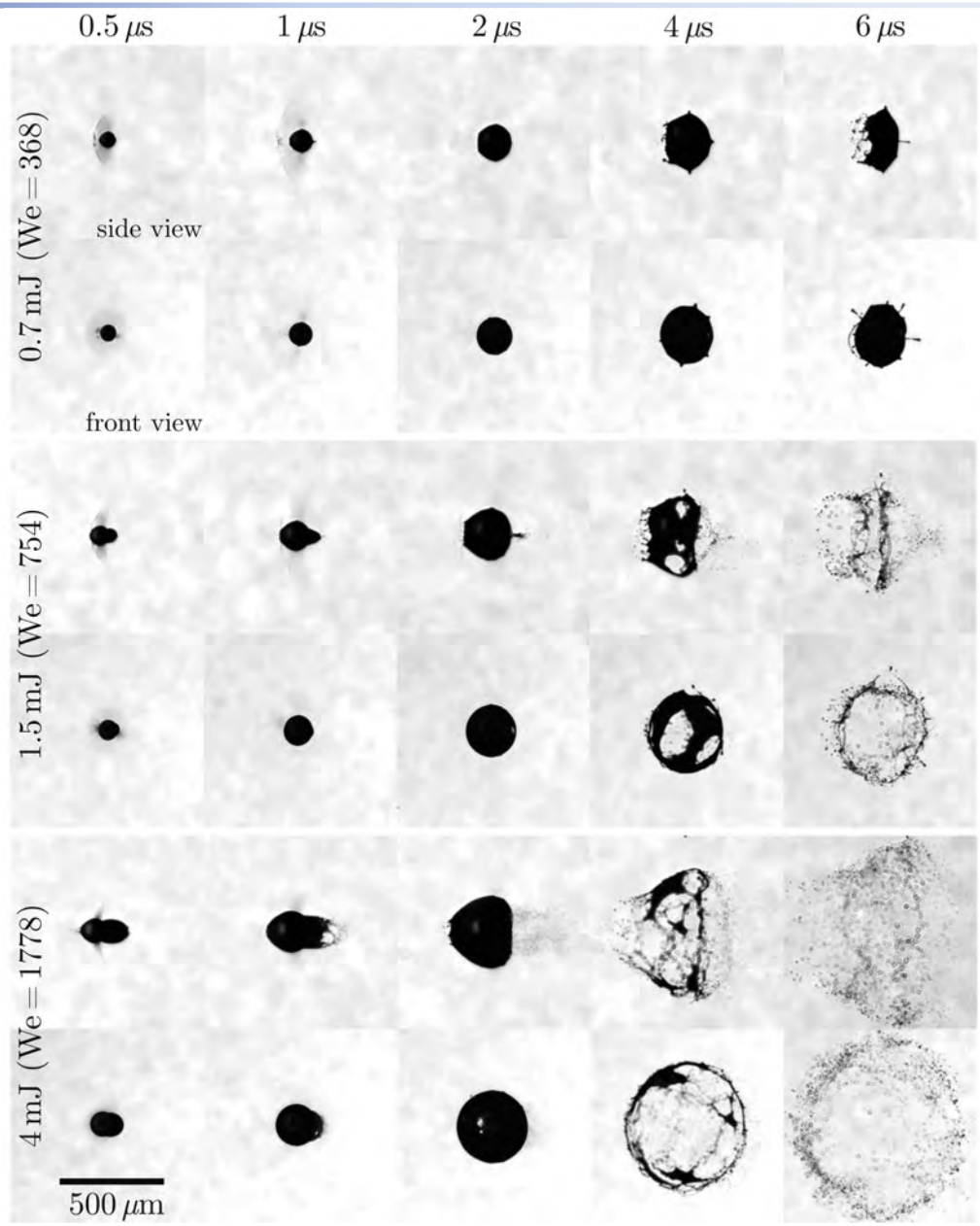
ps-laser-driven droplet expansion

Cavitation and spallation from shockwaves



ISAN, Moscow:
A. Y. Vinokhodov et al, Quant. Electr. **46**, 23 (2016)
M. M. Basko et al, Laser Phys. Lett. **14**, 036001 (2017)
M. Krivokorytov et al, Phys. Rev. E **95**, 031101 (2017)
M. Krivokorytov et al, Sci. Rep., **8** (2018)
D. Kurilovich et al, *arXiv:1805.07283* (2018)

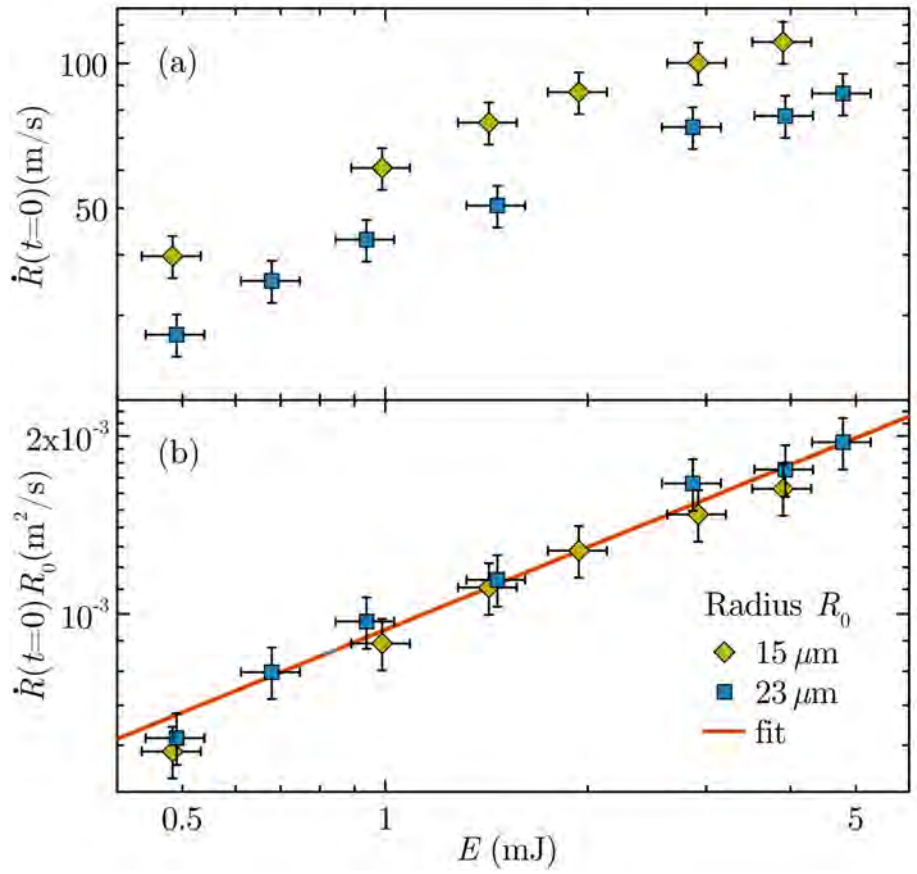
15-ps-pulse impact on tin microdroplets

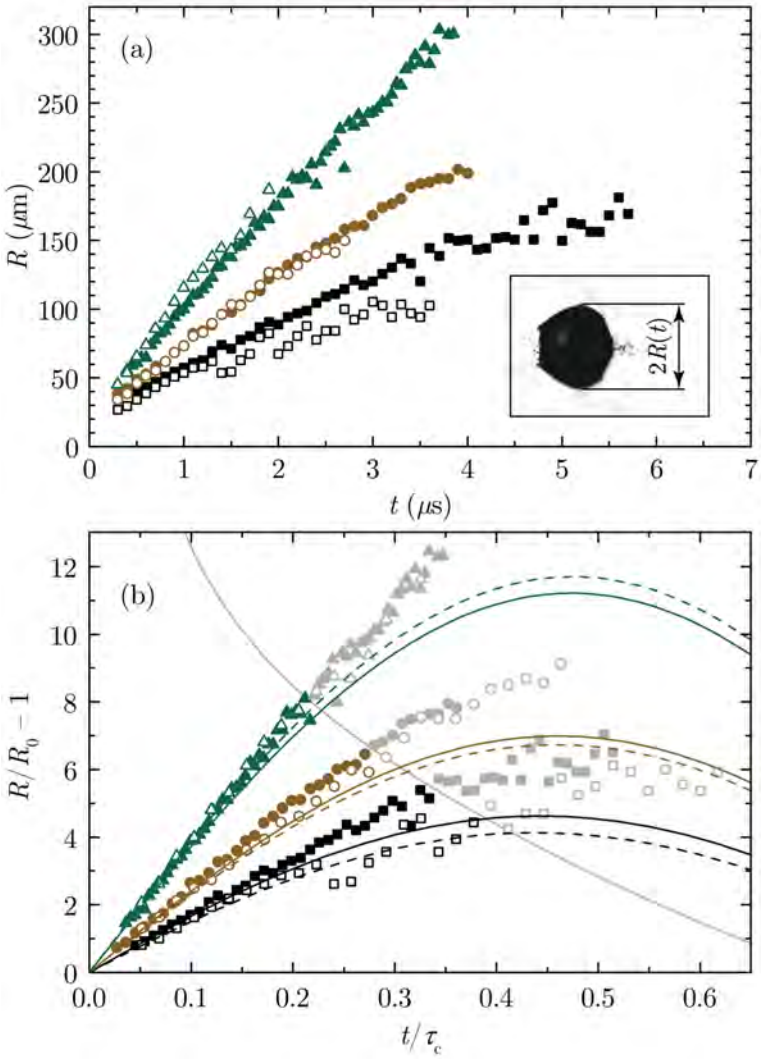


D. Kurilovich et al, *arXiv:1805.07283* (2018)

15-ps-pulse impact on tin microdroplets

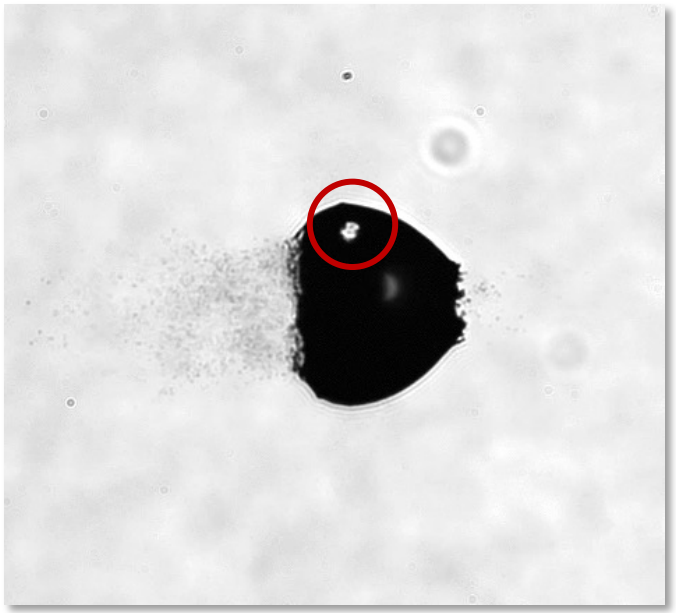
Expansion of the tin shell

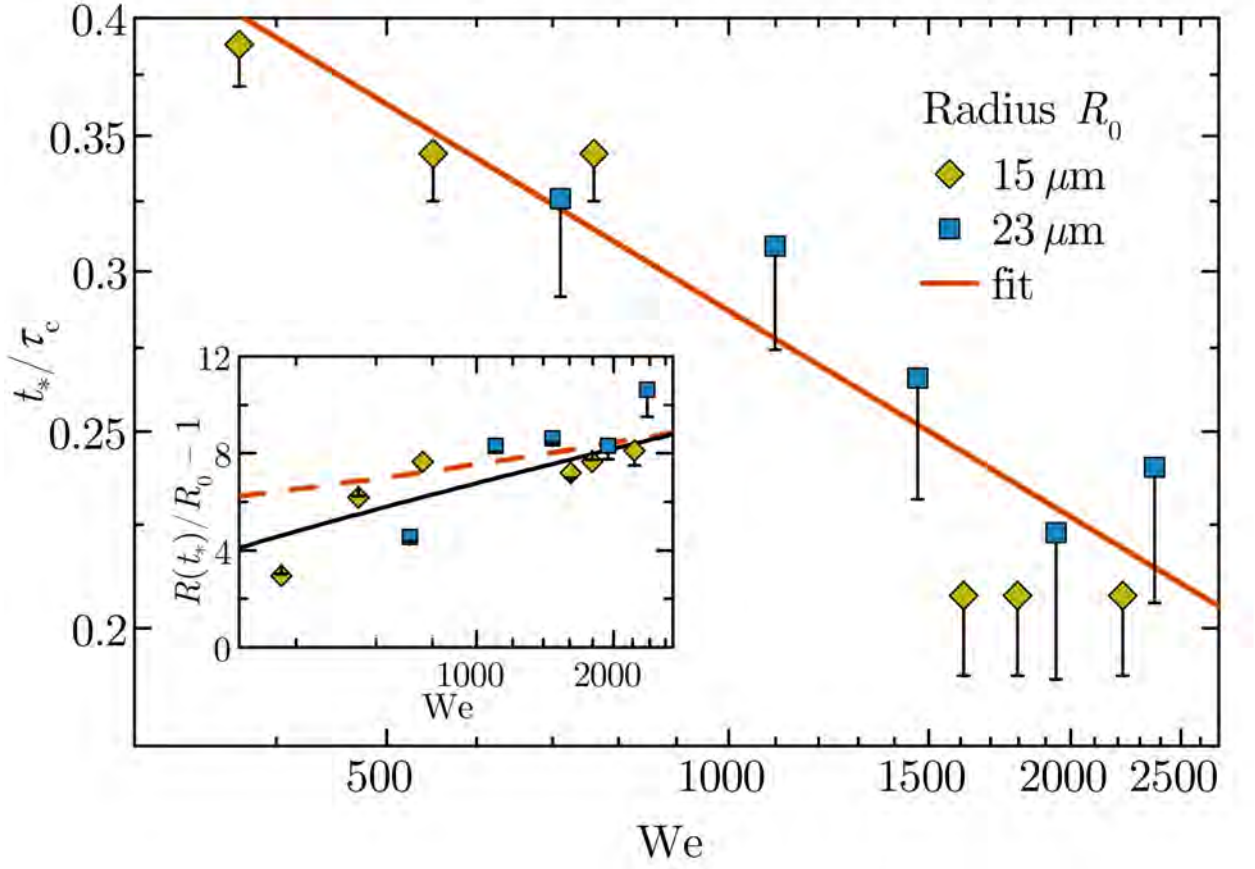




15-ps-pulse impact on tin microdroplets

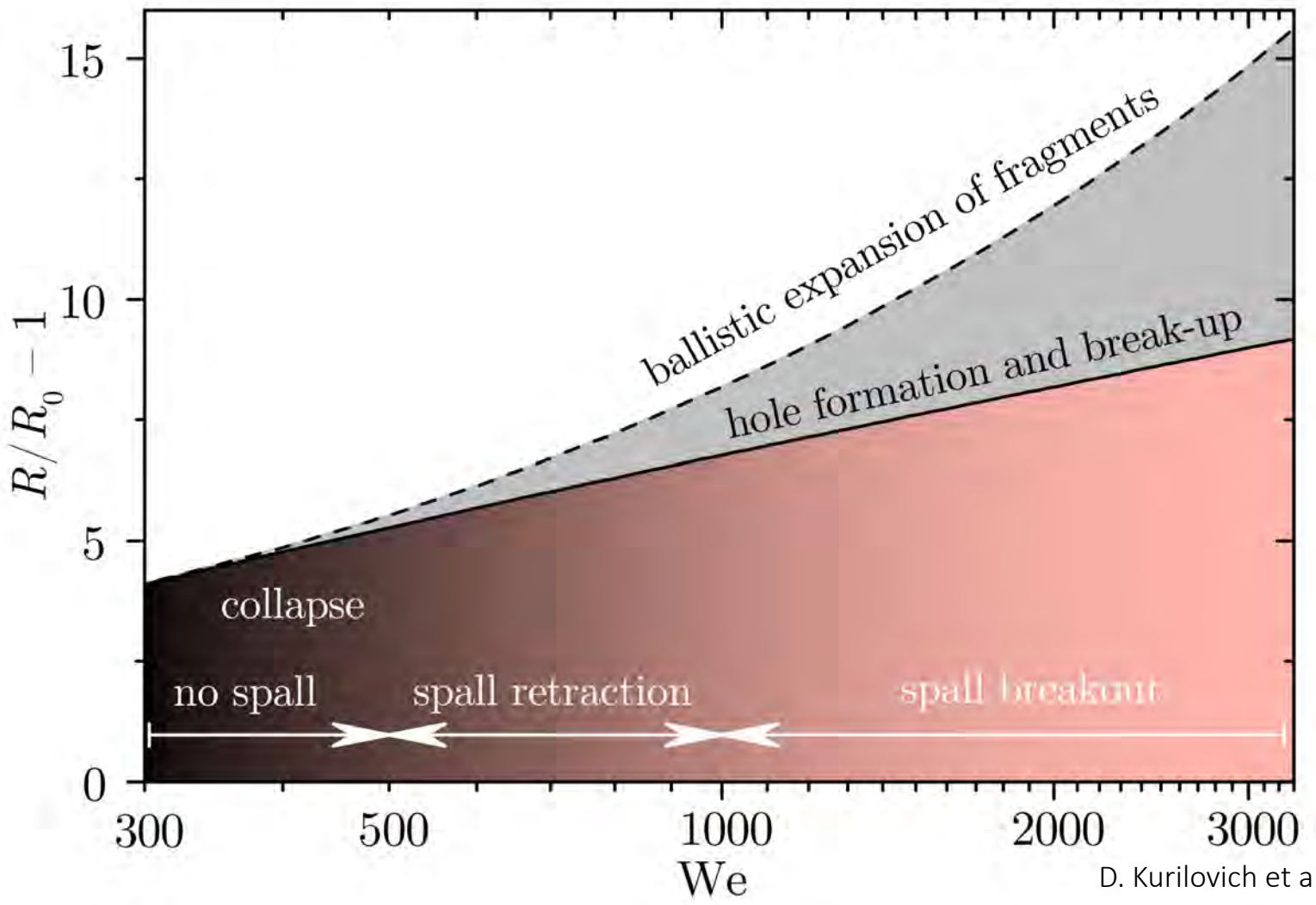
Hole opening time





15-ps-pulse impact on tin microdroplets

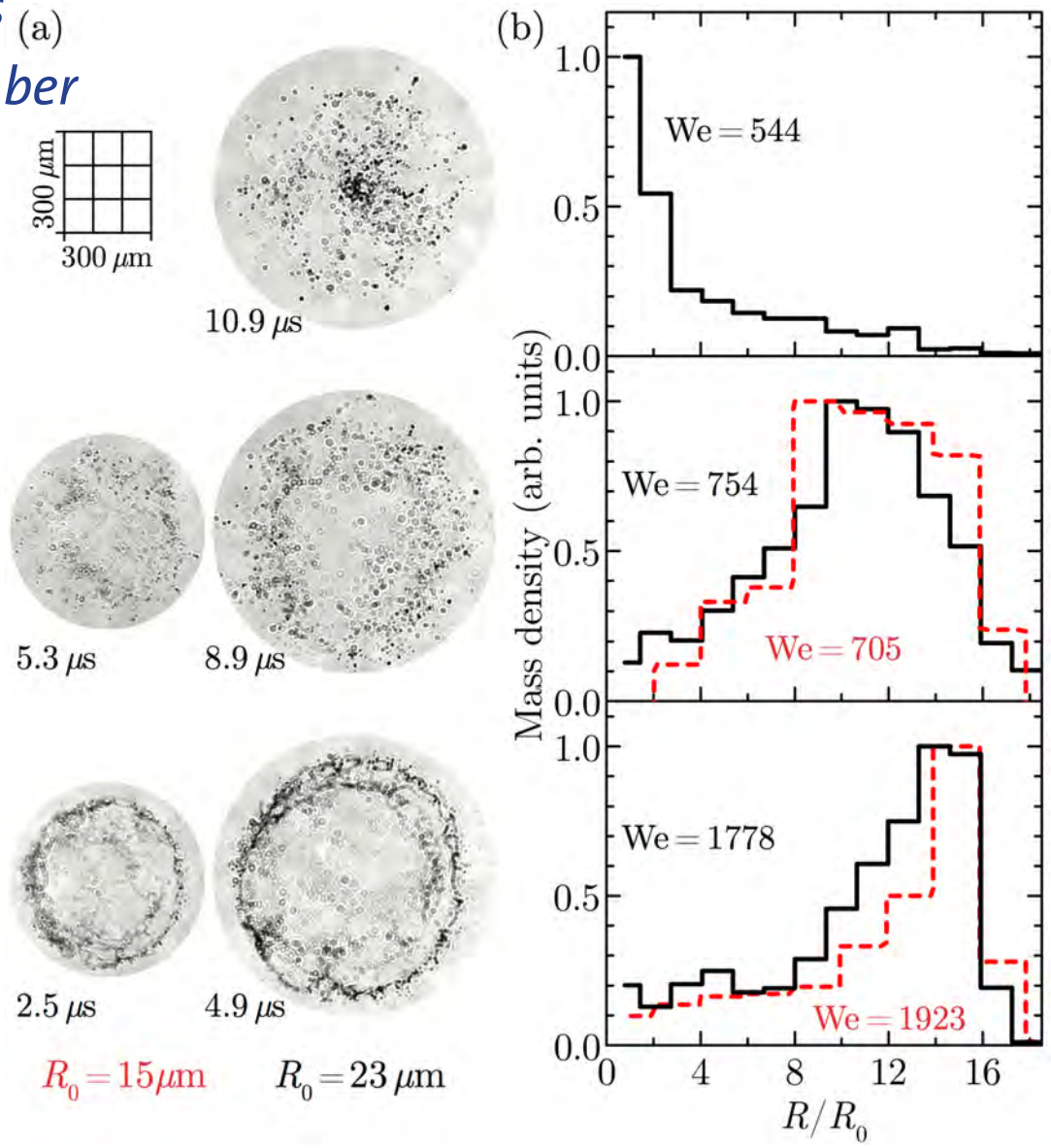
Summary diagram



D. Kurilovich et al, *arXiv:1805.07283* (2018)

15-ps-pulse impact on tin microdroplets

Late-time mass distributions are governed by Weber number

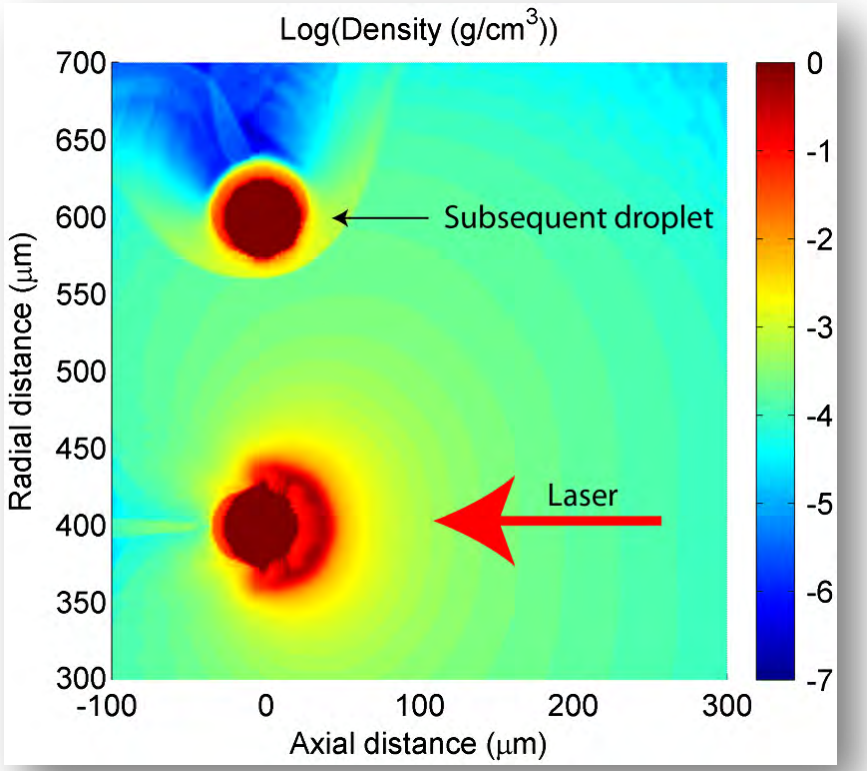


D. Kurilovich et al, *arXiv:1805.07283* (2018)

Plasma-induced pre-deformation of subsequent droplets

l=2 mode of oscillation

Experiment at **ARCNL**

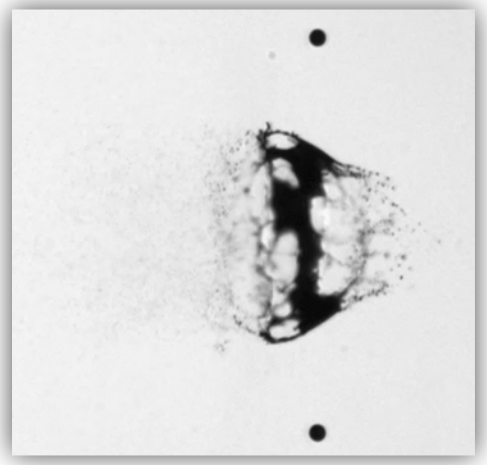


Modeling
from R. S. Abhari, et al.,
J. Micro/Nanolithography, MEMS, and MOEMS, 11(2), 021114 (2012)

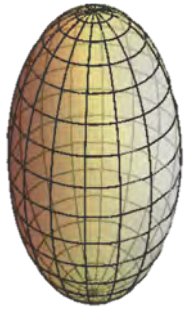
ps-pulse-driven droplet expansion

pre-deformation oblate vs prolate; side views

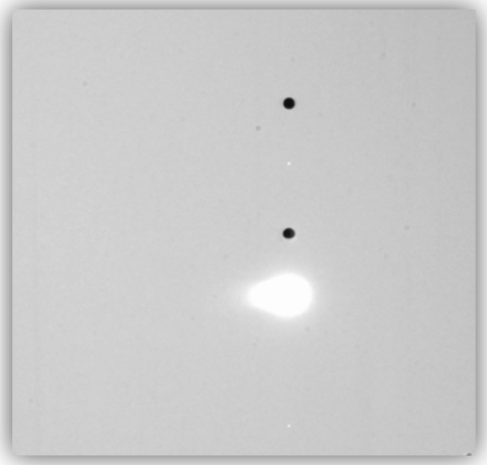
spherical (movie still)

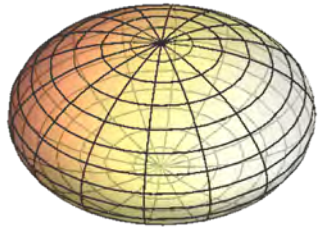


prolate

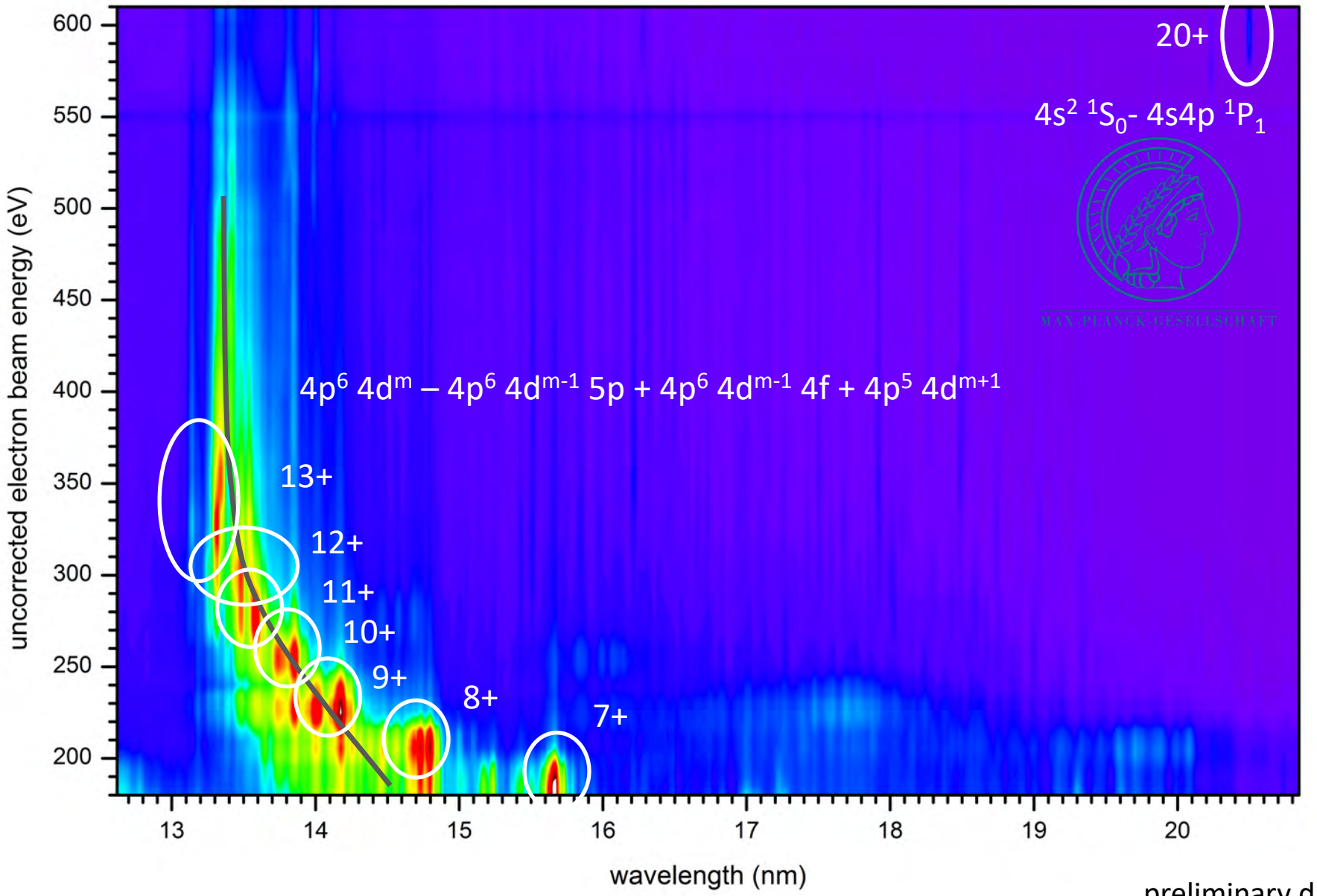


oblate



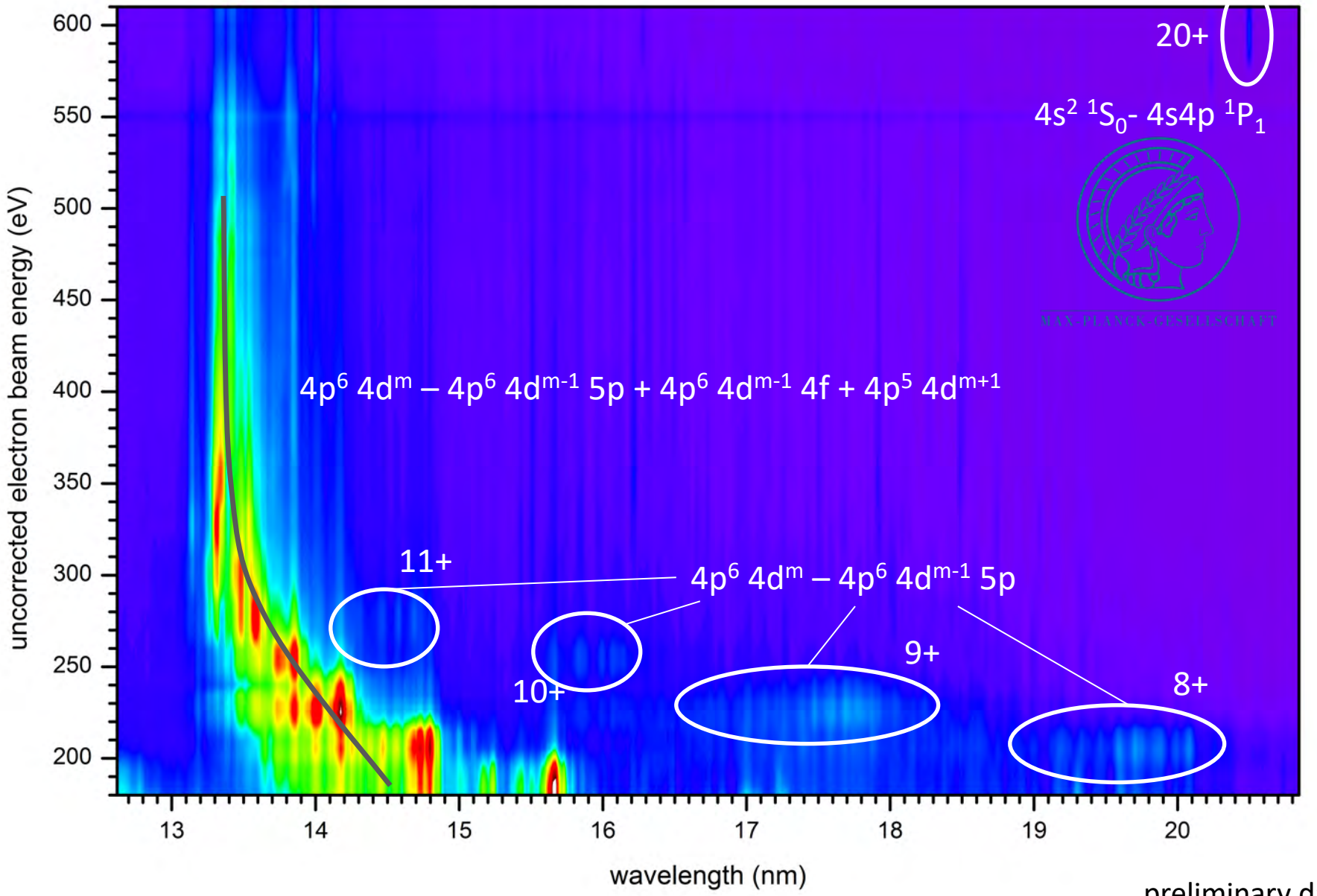


EBIT: Charge-state-resolved spectra



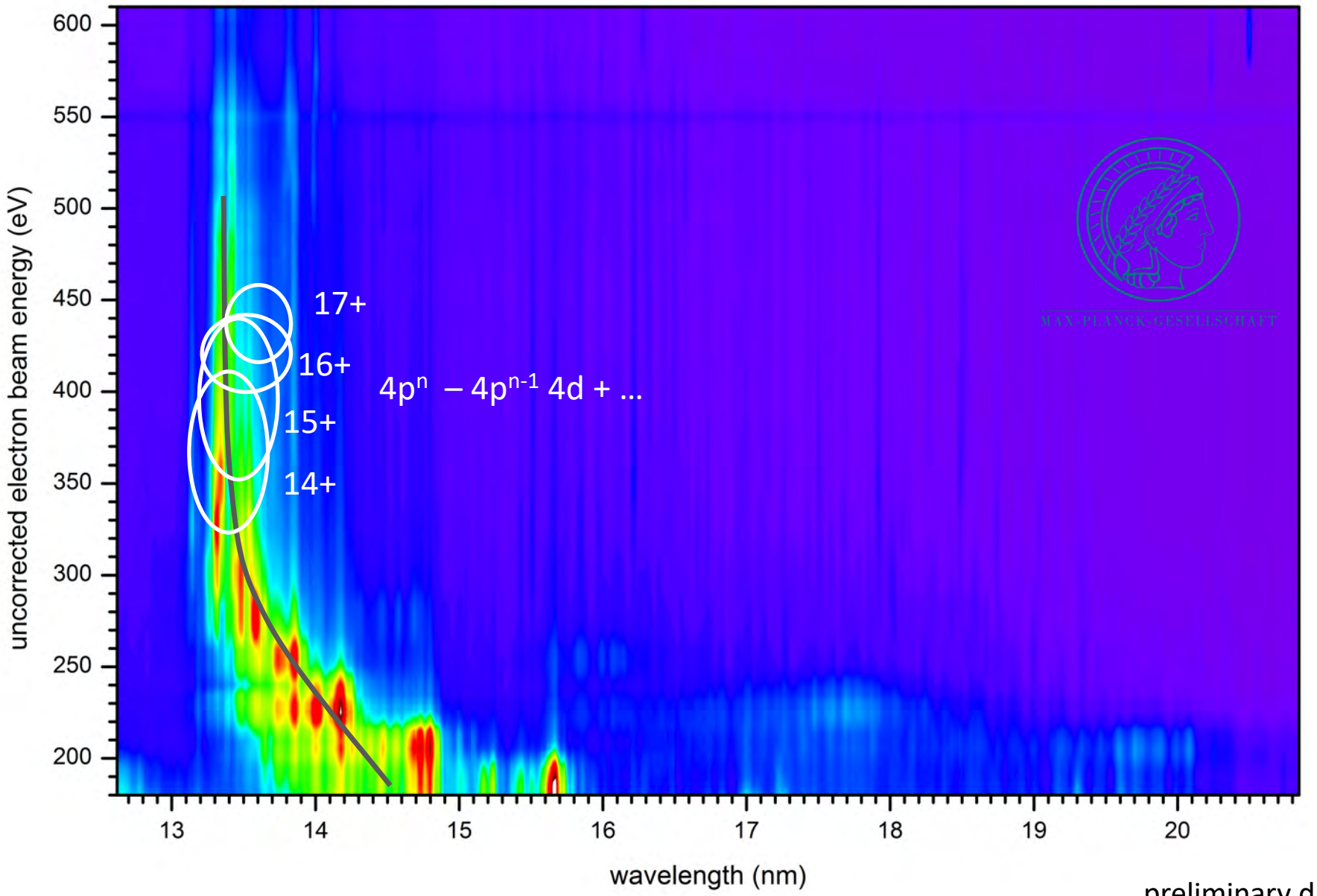
preliminary data

EBIT: Charge-state-resolved spectra



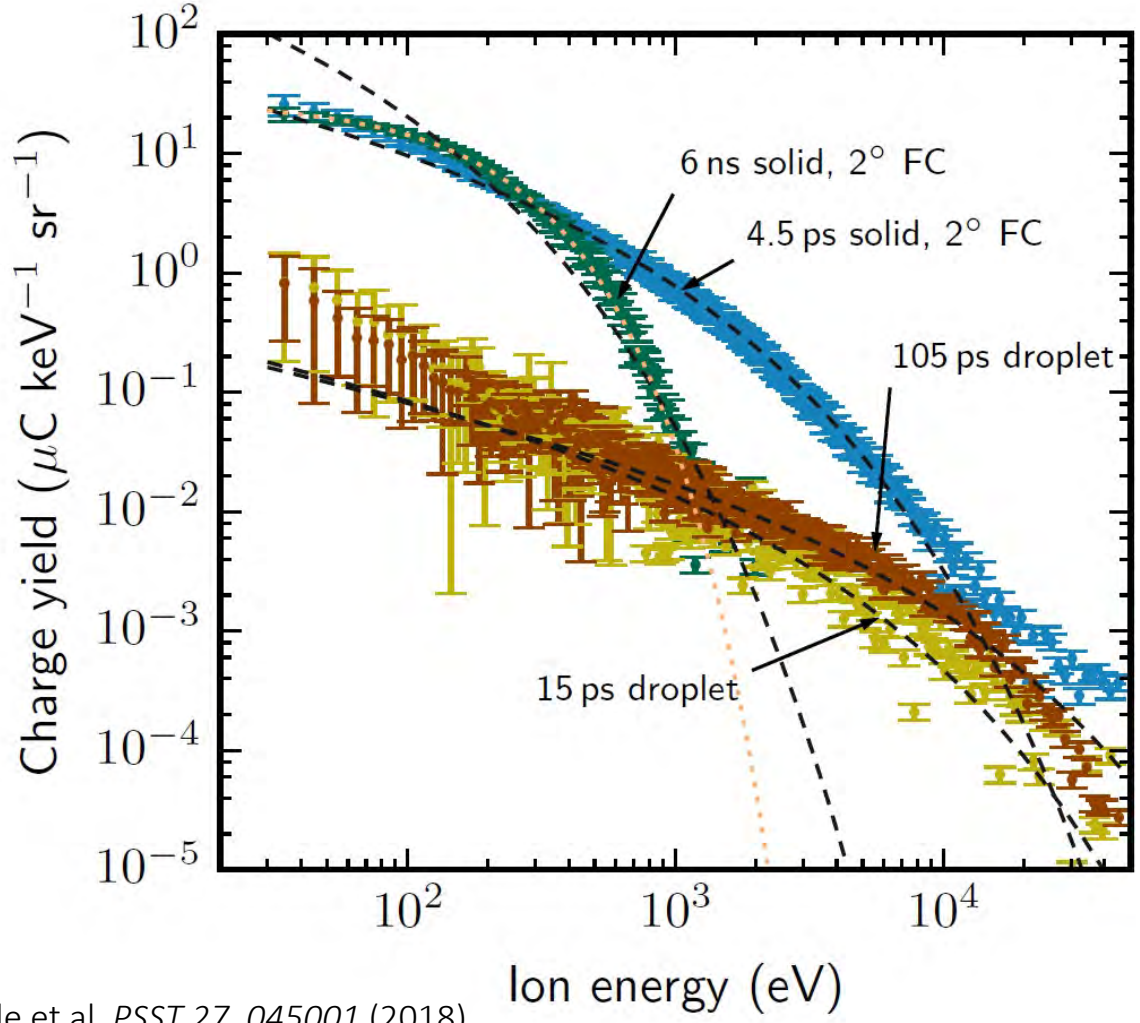
preliminary data

EBIT: Charge-state-resolved spectra



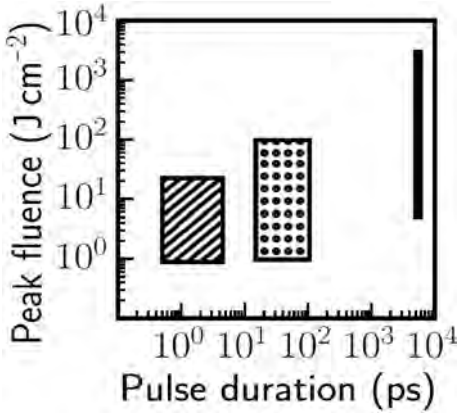
preliminary data

Ion energy distribution



A. Bayerle et al, *PSST 27, 045001* (2018)

Explored range



Self-similar solution by Mora *PRL 90, 185002*

$$dN/dE \propto (E/E_0)^{-1/2} \exp(-\sqrt{E/E_0})$$

Self-similar solution by Murakami *PoP 12, 062706*

$$dN/dE \propto (E/\tilde{E}_0)^{(\alpha-2)/2} \exp(-E/\tilde{E}_0)$$

Acknowledgments

ARCNL

ADVANCED RESEARCH CENTER FOR NANOLITHOGRAPHY

EUV Plasma Processes group


Prof. Wim Ubachs


Prof. Ronnie Hoekstra


Dr. Oscar Versolato


Dr. Alex Bayerle

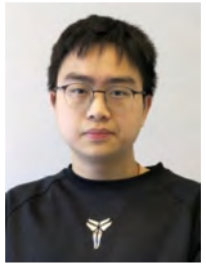

Dr. Laurens van Buuren


Mart Johan Deuzeman


Francesco Torretti


Joris Scheers


Ruben Schupp


Bo Liu

EUV Generation & Imaging group


Prof. Kjeld Eikema


Dr. Stefan Witte


Dr. Aneta Stodolna


Tiago Pinto

University of Twente:
H. Gelderblom
S. Reijers
A. Klein

KIAM (Moscow, Russia):
M. M. Basko
D. A. Kim

AMOLF **- for technical support**